Title:

Modification of Electromagnetic Hybrid Particle-In-Cell Plasma Simulation Model for Robustness Improvement

Authors:

Masaharu Matsumoto[*1], Yoshihiro Kajimura[*1], Masao Nakamura[*2], Hideyuki Usui[*3], Ikkoh Funaki[*1] and Iku Shinohara[*1]

Affiliations:

[*1] Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, JAPAN

[*2] Department of Aerospace Engineering, Osaka Prefecture University, JAPAN

[*3] Department of Computational Science, Kobe University, JAPAN

Abstract:

The common type of electromagnetic hybrid particle-in-cell (PIC) plasma simulation codes is that the ions are treated kinetically as particles and the electrons are modeled as an inertia-less (mass-less) fluid and the electromagnetic field are applied to the low frequency (Darwin) approximation. Hybrid-PIC simulations are used to reasonably simulate plasma phenomena in which ion kinetic effects are important.

To improve the numerical stability, we propose two kinds of numerical procedures for hybrid-PIC codes. The first one is that the discretization method of total variation diminishing (TVD) scheme, which has been widely utilized in computational fluid dynamics over the past two decades, is introduced to the convection term of magnetic induction equation in a hybrid-PIC code. Non-physical, artificial oscillations which would ordinarily be produced in the solution estimated by second-order central difference scheme at discontinuities of magnetic field are drastically prevented by the TVD scheme in numerical results of test simulations. The second one is that the fluid ion component which approximates the cold background plasma component is introduced in order to avoid the numerical divergence of electric field in low plasma density region. The numerical instability originated from the division processes of low plasma number density in generalized Ohm's law can be suppressed by the background fluid ion component.

We will show some examples of hybrid-PIC simulation results in which numerical stability is improved, and will discuss the characteristics of the numerical procedures as mentioned above. Furthermore, for the practical simulations, the simulation of interaction between the solar wind and the mini-magnetosphere of dipolar magnetized objects will be shown.